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# THE BLOOD-PRESSURE IN DIPHTHERIA.

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# THE BLOOD-PRESSURE IN DIPHTHERIA.

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*Assistant Medical Officer, Grove Hospital, London.*

*Historical note.*—Friedemann (1893), working with von Basch's sphygmomanometer, examined 63 children suffering from diphtheria in Heubner's clinique at Leipzig. He found that small oscillations occurred in all cases, but that there were no grounds for anxiety, as long as they were within 5–10 mm. Hg. Provided that the blood-pressure did not sink below 90 mm. in big children, and below 75 mm. in small ones, the prognosis was not unfavourable. Cases showing a reading of 65 or 60 mm. were almost invariably fatal. Friedemann was of opinion that the diagnosis of cardiac involvement and the establishment of convalescence could be made much earlier by the sphygmomanometer than by ordinary clinical methods.

Biernacki (1899) investigated 26 cases, 6 of which were fatal, with the pocket form of Hill and Barnard's instrument, and found that in fatal cases the incidence and intensity of toxic symptoms bore a definite relation to the fall of blood-pressure.

Durand-Viel (1903) used Potain's instrument on 55 diphtheria patients, whose ages ranged from 3½ to 14 years, and found that a fall of pressure took place in every form of diphtheria, mild or severe. The fall was relatively more marked in older children and in severe forms of the disease.

Denis (1903), from observations on 400 children in Marfan's diphtheria wards, arrived at similar conclusions.

Taddei (1904) used Riva-Rocci's original instrument on 164 children, including 14 laryngeal cases before and after intubation. He found that the hypotensive action of diphtheria toxin was not always present in every form of the disease. In mild cases the blood-pressure was almost normal, in moderate cases the depression was slight, and of brief duration, while in toxic forms the hypotension was very marked, though it might be preceded by a slight rise during the febrile stage. The arterial tension bore an inverse relation to albuminuria; the more persistent and massive the albuminuria, the longer and more marked the hypotension. In laryngeal cases the pressure rose until intubation, was at its maximum during the operation, and then gradually fell.

Weigert (1907) examined 46 cases with Gärtner's tonometer. In the mild and uncomplicated cases the pressure on the whole was not affected; in some there was a slight rise during the febrile period. Similar results were obtained in cases with more or less severe myocarditis, in which on the average the pressure did not sink lower than in the mild cases. In 4 fatal cases very low readings were registered (50 mm. in a child aged 11 years, 45 mm. in one aged 9 years, and 40 mm. in one aged 2 years.) Although the patients who recovered did not have such a low blood-pressure as the fatal cases, Weigert did not think that much prognostic value should be attached to sphygmomanometry in diphtheria.

Brückner (1909) examined about 200 cases of diphtheria in the Dresden Children's Hospital with Gärtner's tonometer. At the beginning of the disease he found either a rise with subsequent fall or a subnormal reading from the first. Subsequently the blood-pressure behaved in various ways. Horizontal readings were found in uncomplicated cases, and in those with slight cardiac disturbance. In fatal cases the blood-pressure showed a steadily downward course. Like Weigert, Brückner concluded that the estimation of the blood-pressure in diphtheria is of less value than examination of the heart, liver, and urine, and attention to the patient's colour and general condition.

The present paper is based on observations made on 179 cases of diphtheria admitted to the Grove Hospital in the course of the last eighteen months (July, 1909, to December, 1910). The blood-pressure in each case was taken with C. J. Martin's modification of Riva-Rocci's sphygmomanometer. The systolic pressure, as measured by disappearance of the radial pulse, was alone taken into consideration. As far as possible the measurements were taken at the same time each day between 10.30 a.m. and noon, *i. e.* from 1½ to 5 hours after food; in many cases an evening record between 6.30 p.m. and 7 p.m. was also made. The blood-pressure was taken daily in each case until the patient was allowed to sit up, *i. e.* for a period ranging from three weeks in the mild cases to six or eight weeks in the severe. Comparative observations were subsequently made on the different readings in the recumbent and erect positions. Apart from the early fatal cases the total period of observation in each case ranged from four to fourteen weeks.

*Age and sex.*—Table I shows that all the patients, except 15 who were above the age of fifteen years, were children. Ninety were males, 89 were females. There was no appreciable difference in the blood-pressure of any two individuals of different sexes, but of the same age and suffering from attacks of diphtheria of equal severity.

TABLE I.

| Years. | Males. | Females. |
|---|---|---|
| 0–1 | 1 | 0 |
| 1–2 | 2 | 3 |
| 2–3 | 9 | 4 |
| 3–4 | 8 | 3 |
| 4–5 | 9 | 14 |
| 5–6 | 17 | 21 |
| 6–7 | 5 | 9 |
| 7–8 | 9 | 12 |
| 8–9 | 3 | 4 |
| 9–10 | 6 | 4 |
| 10–11 | 5 | 0 |
| 11–12 | 2 | 3 |
| 12–13 | 3 | 2 |
| 13–14 | 2 | 0 |
| 14–15 | 3 | 1 |
| 15–47 | 6 | 9 |
| | 90 | 89 |

*Normal blood-pressure.*—As the blood-pressure of the patients prior to their attack of diphtheria was not known, it is necessary to compare the readings taken with those made by other observers on normal children.

Table II shows the figures obtained by Seiler from observations on normal children with Riva-Rocci's instrument.

TABLE II.

| Years. | Maximum pressure. mm. Hg. |
|---|---|
| 2–3 | 75–80 |
| 4–5 | 79–90 |
| 6–7 | 85–95 |
| 8–9 | 90–95 |
| 10–11 | 93–96 |
| 12–13 | 94–106 |
| 14–15 | 93–104 |
| 15–16 | 103–120 |

The figures of Cook and Briggs obtained with their own modification of Riva-Rocci's instrument are somewhat higher. According to them the blood-pressure of children up to two years was from 75–90 mm., for children after two years 90–110 mm., and for young adults 130 mm. In women the blood-pressure was 10–15 mm. lower than in men.

*Blood-pressure in diphtheria.*—Of the 179 cases, 63, or 35·1 per cent., according to Cook and Briggs's estimate, and 45 cases, or 25·1 per cent., as judged by Seiler's standard, showed for varying periods a pressure inferior to the normal. Owing to the well-known depressive effects of diphtheria toxins these figures may appear surprisingly low, but are to be explained by the inclusion of a large number of mild cases, in whom the blood-pressure was not lowered in the course of their illness. As will be shown below, the varying degrees of depression bore a direct relation to the severity of the attack, being pronounced and persistent in the severe, and slight and transitory in the mild cases.

Of those whose blood-pressure was not lowered, 36 cases, or 20·1 per cent., according to Seiler's standard showed a reading which always exceeded the normal. Judged, however, by the more liberal estimate of Cook and Briggs the pressure of these cases did not persistently rise above the normal limits.

*Classification of cases.*—The cases have been ranged according to the severity of the faucial attack in the following 4 classes:

Table III.

| | | |
|---|---|---|
| Class I . . | Very severe . | 22 cases. |
| „ II . . | Severe . . | 59 „ |
| „ III . . | Moderate . . | 41 „ |
| „ IV . . | Mild . . . | 57 „ |

*Affection of blood-pressure in each class : Class I.*—The hypotensive effect of diphtheria was naturally most marked in this class; 18 cases, or 81·1 per cent. according to Cook and Briggs's standard, and 17, or 77·2 per cent. according to Seiler's, showed readings from 5 to 45 mm. below the normal. The fall in pressure occurred rapidly and steeply, and was considerable from day to day, *e. g.* from 110 mm. on the second day to 68 mm. on the third, or there might be a difference of over 10 mm. between the morning and evening readings, or lastly—and this was of still graver prognosis—a marked difference between the readings at the two wrists.

The following readings may be regarded as typical of early fatal cases in this class:

TABLE IV.

| Age. | Day of disease on admission. | Blood-pressure on admission. | Subsequent records. |
|---|---|---|---|
| 5 years | 4th | 110 | 106, 102, 94, 86 morn., 70 morn., 40, 68.<br>70 even., 50 even.<br>Death on 11th day. |
| 6 ,, | 10th | 100 | 100, 90, 80, 70 R. wrist, 70 R. wrist<br>60 L. wrist, 50 L. wrist<br>Death on 17th day. |
| 7 ,, | 5th | 110 | 110, 110, 100, 90, 90, 86, 80, 70, 90, 66.<br>Death on 15th day. |

In cases which recovered the pressure after the initial fall tended to remain stationary apart from slight oscillations, probably of psychical origin, before returning to the normal level. As will be seen below, a subsequent fall preceding or accompanying the late paralysis, which was naturally most frequent in this class, was very exceptional.

None of the cases in this class showed readings above the normal, except during the first few days of the disease. In every case the pressure was lower than on admission by the time the throat was clean or before death, in 2 by 10 mm.; in 2 by more than 10, but less than 20 mm.; in 2 by 20 mm.; and in 8 by 30 to 60 mm. The difference between the highest and lowest records in any one case was considerable, *e. g.* in 1, 30 mm.; in 7, 40 to 50 mm.; in 1, 60 mm.; and in 1, 70 mm.

*Class II.*—The fall in pressure, though less marked than in Class I, was still considerable; 25 cases, or 42·3 per cent., according to Cook and Briggs's standard, and 16 cases, or 27·1 per cent., according to Seiler's, showed readings varying from 3 to 24 mm. below normal during a period of from 1 to 41 days' duration. The lesser degree of hypotension than in Class I is shown by the following figures: In 16 the pressure on the day on which the throat was clean was the same as on admission, in 14 it was 10 mm. or less than on admission, and in 12 the fall exceeded 10 mm. by amounts varying from 14 to 30 mm. The greatest difference between the highest and lowest readings was 40 mm., which was found in 4 cases.

The course of the blood-pressure in the acute stage is illustrated in the following table :

TABLE V.

| Age. | Day of disease on admission. | Blood-pressure on admission. | Subsequent readings in acute stage. |
|---|---|---|---|
| 5 years | 6th | 130 | 120, 120, 106. |
| 5 ,, | 7th | 100 | 90, 90, 84, 80. |
| 8 ,, | 8th | 110 | 100, 100, 100, 90. |
| 9 ,, | 8th | 100 | 90, 80, 70.<br>Death on 10th day. |
| 15 ,, | 4th | 122 | 116, 120, 110, 116, 110, 104. |

*Class III.*—The fall in pressure was still less marked than in Class II; 11 cases, or 26·8 per cent., according to Cook and Briggs's standard, and 6 cases, or 14·6 per cent., according to Seiler's, showed a subnormal reading of from 1 to 14 mm. for a period varying from 2 to 37 days.

The greatest difference between the highest and lowest readings was 38 mm., which was registered in 1 case. In only 4 faucial cases was there a difference of more than 20 mm. between the two extremes. Among the purely faucial cases the pressure on the day on which the throat was clean was the same as on admission in 8, in 2 it was higher, and in 19 it was lower by from 10 to 20 mm.

TABLE VI.—*Shows Typical Readings in the Acute Stage.*

| Age. | Day of disease on admission. | Blood-pressure on admission. | Subsequent readings in acute stage. |
|---|---|---|---|
| 4 years | 4th | 110 | 102, 100, 92. |
| 6 ,, | 3rd | 110 | 112, 104, 102, 100. |
| 7 ,, | 2nd | 120 | 110, 124, 120, 110. |

*Class IV.*—The blood-pressure was least affected in this class; in only 2 cases, or 5·2 per cent., according to Seiler's standard, and 8 cases, or 15·7 per cent., according to Cook and Briggs, was a subnormal reading registered. According to Seiler's standard the fall never exceeded 5 mm., nor lasted more than two days, according to Cook and Briggs's standard the fall did not exceed 10 mm., and was present from 3 days to a month. In 17 cases, or 29·8 per cent., according to Seiler's scale, the pressure was always above normal ; while according to Cook and Briggs, though occasionally, it was never persistently so.

In 16 of the purely faucial cases the pressure on the day on which the throat was clean was the same as or less than 10 mm.

than on admission, and in 5 there was a rise of 10 mm. or less. In only 5 did the difference between the highest and lowest reading in any case reach 30 mm.; in 19 it ranged from 20 to 30 mm., and in 9 from 10 to 20 mm.

TABLE VII.—*Shows Typical Readings in the Acute Stage.*

| Age. | Day of disease on admission. | Blood-pressure on admission. | Subsequent readings in acute stage. |
|---|---|---|---|
| 2 years | 6th | 96 | 96, 100, 102 |
| 5 „ | 2nd | 100 | 102, 100, 90, 110 |
| 6 „ | 3rd | 100 | 100, 100, 100, 100 |
| 7 „ | 2nd | 104 | 110, 110, 110, 110 |
| 8 „ | 2nd | 108 | 110, 110, 106, 106 |

*Date of highest and lowest blood-pressure.*—The following tables show the date at which the maximum and minimum blood-pressures in each class were registered. In the overwhelming majority the highest reading was obtained in the first week, and the lowest in the second week.

TABLE VIII.—*Showing the Number of Cases in Each Week in which Highest Readings were Recorded.*

| | 1st week. | 2nd week. | 3rd week. | 4th week. | 5th week. | 6th week. | 7th week. | 8th week. |
|---|---|---|---|---|---|---|---|---|
| Class I. | 17 | — | 2 | 2 | 1 | — | — | — |
| „ II. | 40 | — | 6 | — | — | 8 | 4 | 1 |
| „ III. | 31 | 4 | 0 | 1 | 1 | 4 | — | — |
| „ IV. | 42 | 7 | 1 | 3 | 2 | 2 | — | — |
| | 130 | 11 | 9 | 6 | 4 | 14 | 4 | 1 |

TABLE IX.—*Showing the Number of Cases in Each Week in which Lowest Readings were Recorded.*

| | 1st week. | 2nd week. | 3rd week. | 4th week. | 5th week. | 6th week. | 9th week. | 10th week. |
|---|---|---|---|---|---|---|---|---|
| Class I. | 4 | 14 | 3 | 1 | — | — | — | — |
| „ II. | 7 | 29 | 13 | 3 | 3 | 2 | 1 | 1 |
| „ III. | 7 | 21 | 5 | 8 | — | — | — | — |
| „ IV. | 15 | 33 | 7 | 2 | — | — | — | — |
| | 33 | 97 | 28 | 14 | 3 | 2 | 1 | 1 |

In 97 of the 130 cases admitted in the first week of disease and in 10 of the 15 cases admitted in the second week, the highest reading was the first taken. The occurrence of the comparatively high pressures in the first week is to be attributed partly to the febrile disturbance of the acute stage before the diphtheria toxins had had time to produce their characteristic effect, and partly to the psychical action caused by the application of an unfamiliar instrument, the latter fact accounting for the highest reading being usually obtained on the first measurement. The preponderance of the lowest readings in the second week accords with the clinical fact that this is the time of predilection for the so-called "cardiac paralysis," which should more accurately be called vaso-motor paralysis, the heart failure being secondary to the vaso-motor affection. All forms of this palsy may exist, and in accordance with the rule in diphtheritic paralysis, only a small minority prove fatal. Apart from one case of diaphragmatic paralysis, all the deaths in the present series were due to this cause, fifteen occurring in Class I, and two in Class II, constituting a mortality of 9·4 per cent. As regards the highest pressures recorded, it may be noted that in two neurotic sisters, aged 9 and 7 years respectively, the readings ranged between 130 and 148 mm. Hg. for a month. Another neurotic child, a boy, aged 10 years, had a pressure of from 126 to 144 mm. from the twenty-second to the forty-ninth day of disease.

The lowest reading in a case which recovered was 60 mm., which was registered on one occasion in a girl, aged 3 years. In only ten other cases which recovered did the pressure fall below 80 mm. in patients above the age of 2 years. Two of these belonged to Class I, five to Class II, and three to Class IV.

The date at which the pressure in forty cases returned to the normal, according to Cook and Briggs's standard, after the initial fall is shown in Table X, from which it is seen that in the great majority the normal tension was regained by the end of the seventh week.

Table X.

| | 2nd week. Cases. | 3rd week. Cases. | 4th week. Cases. | 5th week. Cases. | 6th week. Cases. | 7th week. Cases. | 8th week. Cases. | 9th week. Cases. | 11th week. Cases. |
|---|---|---|---|---|---|---|---|---|---|
| Class I. | — | 2 | 1 | — | — | — | — | — | 1 |
| ,, II. | 2 | 2 | 1 | 4 | 4 | 2 | — | 2 | — |
| ,, III. | 2 | 2 | 1 | 1 | 1 | 4 | 2 | — | — |
| ,, IV. | 2 | 1 | 1 | 1 | — | 1 | — | — | — |
| | 6 | 7 | 4 | 6 | 5 | 7 | 2 | 2 | 1 |

*Relation of blood-pressure to pulse-rate.*—The blood-pressure being much more stable than the pulse-rate, it is not surprising that there should be no exact relation between them. As a general rule, however, the highest pulse-rate, like the highest blood-pressure, occurred during the first week of disease, and the lowest pulse-rates were found in the second week, when the blood-pressure was usually lowest. The following tables show the exact figures.

TABLE XI.—*Showing Weeks of Highest Pulse-rate.*

| | 1st week. Cases. | 2nd week. Cases. | 3rd week. Cases. | 4th week. Cases. | 5th week. Cases. | 6th week. Cases. | 7th week. Cases. |
|---|---|---|---|---|---|---|---|
| Class I. | 17 | 3 | 1 | 1 | — | — | — |
| „ II. | 41 | 9 | 2 | 1 | 2 | 3 | 1 |
| „ III. | 32 | 6 | 1 | 2 | — | — | — |
| „ IV. | 51 | 3 | 1 | — | 1 | — | 1 |
| | 141 | 21 | 5 | 4 | 3 | 3 | 2 |

TABLE XII.—*Showing Week of Lowest Pulse-rate.*

| | 1st week. Cases. | 2nd week. Cases. | 3rd week. Cases. | 4th week. Cases. | 5th week. Cases. | 6th week. Cases. |
|---|---|---|---|---|---|---|
| Class I. | 7 | 10 | 3 | 1 | 1 | — |
| „ II. | 3 | 38 | 8 | 7 | 2 | 1 |
| „ III. | 4 | 22 | 11 | 3 | 1 | — |
| „ IV. | 7 | 38 | 10 | 1 | 1 | — |
| | 21 | 108 | 32 | 12 | 5 | 1 |

*Comparative readings in the recumbent and erect positions.*—Table XIII shows the readings in the recumbent and erect positions in 103 patients in whom these comparative observations were made.

TABLE XIII.

| | Cases examined. | Both readings same. | Recumbent higher than erect. | Erect higher than Recumbent. |
|---|---|---|---|---|
| Class I. | 4 | 2 | 1 | 1 |
| „ II. | 39 | 18 | 12 | 9 |
| „ III. | 29 | 14 | 5 | 10 |
| „ IV. | 31 | 14 | 14 | 3 |
| | 103 | 48 | 32 | 23 |

It is noteworthy that whereas in normal persons the pressure in the erect position is 5 to 10 mm. higher than in the recumbent (Janeway, Cooke and Briggs), in a large percentage of the present series the two readings were either the same, or the reading in the recumbent was higher than in the erect position by from 2 to 20 mm.

Thus, out of 103 in whom the comparison was made, in 48 the two readings were the same, in 32 the readings when recumbent were higher than when erect, and in only 23 was the normal relation found.

This paradoxical result was by no means confined to the severe cases, and was even more frequent in the mild, but this may have been due to the fact that members of Classes I and II were kept in bed for a much longer time than those of Classes III and IV, who were usually allowed to get up in the course of the third or beginning of the fourth week. The prolonged rest in bed which was enforced in the severe cases probably enabled their cardio-vascular system in some cases to make a more complete recovery from the infection than had been realised in the milder cases. As a rule, however, the normal condition was finally re-established before discharge from hospital, though a period might intervene in which the highest reading might be found sometimes in the one and sometimes in the other position.

This reversal of the ordinary relations between the erect and recumbent readings is liable to occur in convalescence from any acute disease. It is interesting to note as illustrating a similar cardio-vascular instability in convalescence from scarlet fever, that among 80 patients under my care, the paradoxical reading was found in 34 cases, or 42·5 per cent. In 18 of these the readings were the same in both positions, and in 16 the recumbent exceeded the vertical records by 4 to 20 mm.

Similar observations were made by Oddo and Achard, who denominated the fall of blood-pressure following slight exertion in convalescence "the hypotension of effort." Those observers found that this phenomenon is accompanied by other signs of cardio-vascular depression, such as weakness of the first sound, tachycardia, arrhythmia, hypostatic vaso-dilatation of the lower limbs in the erect position, and dermatographia. The practical significance of these observations is to indicate that resumption of muscular work should be gradual in patients presenting the phenomenon of effort hypotension, and should be accompanied, if necessary, by the administration of cardiac and vascular tonics.

*Blood-pressure in laryngeal cases.*—Forty-two cases, or 23·4 per cent., showed various degrees of laryngeal involvement. In 13 *severe* cases tracheotomy was performed; in 11 *moderate* cases the symptoms, though fairly well marked, did not require surgical interference; in 18 *mild* cases the laryngeal symptoms consisted merely of a croupy cough and husky voice, thus representing the first degree of croup of earlier writers.

*Severe cases.*—The effect of laryngeal obstruction on the blood-pressure was most marked in this class. Increase in dyspnœa was followed by a rise of pressure, and the relief of the obstruction on opening the trachea was immediately followed by a considerable fall.

The disproportionately high pressure in relation to the age and the rapid fall on relief of obstruction are illustrated in the following table:

TABLE XIV.

| | Age. | Blood-pressure immediately before tracheotomy. | Blood-pressure immediately after tracheotomy. |
|---|---|---|---|
| Case 1 | 2 years | 120 mm. | 82 mm. |
| „ 2 | 2 „ | 110 „ | 80 „ |
| „ 3 | 3 „ | 110 „ | 80 „ |
| „ 4 | 3 „ | 134 „ | 94 „ |
| „ 5 | 4 „ | 130 „ | 102 „ |
| „ 6 | 4 „ | 140 „ | 120 „ |
| „ 7 | 5 „ | 120 „ | 108 „ |
| „ 8 | 5 „ | 120 „ | 90 „ |
| „ 9 | 5 „ | 140 „ | 100 „ |
| „ 10 | 5 „ | 140 „ | 120 „ |

*Moderate laryngeal cases.*—The rise of blood-pressure in this class was less than in the severe, but the disproportion between the ages and the tension, especially when judged by Seiler's standard, was still obvious, as is shown by the following figures:

TABLE XV.

| Age. | Blood-pressure on admission. | Subsequent readings. |
|---|---|---|
| 11 months | 118 | 80. |
| 2 years | 110 | 100, 90. |
| 3 „ | 120 | 100, 94, 80. |
| 4 „ | 130 | 124, 110, 104, 100. |
| 5 „ | 124 | 114, 108, 104, 100. |
| 5 „ | 140 | 140, 120, 110, 100. |

*Mild laryngeal cases.*—The blood-pressure in this class during the acute stage was not any higher than in the purely faucial cases, in fact, it may be said to have been dominated by the character of the concomitant faucial attack.

TABLE XVI.

| Age. | Blood-pressure on admission. | Subsequent readings. |
|---|---|---|
| 2 years | 100 | 90. |
| 4 " | 96 | 96, 86. |
| 5 " | 110 | 90, |
| 5 " | 112 | 110, 106. |
| 5 " | 100 | 90, 110, 100. |

*Relation of blood-pressure to serum phenomena.*—In the great majority of early serum rashes, erythematous or urticarial, no change occurred in the pressure, while in a large percentage of late eruptions, which are usually associated with febrile disturbance and often with pains in the joints, muscles and fasciæ, the pressure was raised. Thus of 77 cases at the time of the early eruption, 62 patients, or 80·5 per cent., showed no change in the pressure, in 9 it was raised, and in 6 it was lowered. On the other hand, out of 50 with late rashes, in 20 cases, or 40 per cent., the pressure was raised, in 28, or 56 per cent., there was no change, and in only 2 cases, or 4 per cent., it was lowered.

The rarity of any rise in pressure at the time of the early rash is in keeping with the fact that during the second week of disease, in which most of these rashes occur, the pressure is usually at its lowest. In the third week, in the course of which the late serum phenomena occur, the pressure as a rule is no longer falling, while on the other hand the fever and joint pains tend to raise it.

*Blood-pressure in relation to albuminuria.*—As arterial hypotension and albuminuria are both phenomena of diphtheritic intoxication, any change in the blood-pressure co-existent with the occurrence of albuminuria was almost invariably in a downward direction. Thus among 51 cases in whom albuminuria was not present on admission, its onset was accompanied by a fall in the pressure in 26, and in 25 there was no change; in another 8 cases increase of pre-existent albuminuria was accompanied by a fall in the pressure. The solitary exception to the rule occurred in a girl, aged six years, in whom severe faucial diphtheria was complicated on the twenty-ninth day by uræmic convulsions, one of the rarest events in diphtheria. On the two following days the blood-pressure, which up till then had not been examined, stood at the disproportionately high figure of 120 mm., falling on the thirty-second day to 80 mm. Death took place on the thirty-third day.

Albuminuria in diphtheria thus offers a striking contrast to scarlatinal albuminuria, during which it is usual for the blood-pressure to be raised. Thus in eleven such cases I found a rise in all but two.

*Relation of blood-pressure to diphtheritic paralysis.*—The question as to whether the pressure is affected by the occurrence of diphtheritic paralysis is best answered by discussing separately the early and late palsies in this connection.

The early palsies are those which occur within the first fourteen days, and include only the so-called "cardiac paralysis" and the precocious form of palatal paralysis. The late palsies are those which occur at any time after the end of the second week, and include ocular, pharyngeal and diaphragmatic palsies, as well as the ordinary form of palatal paralysis. The extent to which the blood-pressure is affected on development of these palsies is shown in Table XVII, from which it is seen that any change in the blood-pressure at the time of early paralysis was invariably in a downward direction, while during late paralysis a fall in the pressure was most exceptional.

TABLE XVII.

| | Rise of blood-pressure. Cases. | Fall. Cases. | No change. Cases. |
|---|---|---|---|
| Early palsies | 0 | 17 | 6 (Palatal palsy only) |
| Late palsies | 18 | 2 | 31 |

There is nothing surprising in the fact that ocular and palatal palsies were not attended with any fall of pressure, but it is remarkable that pharyngeal paralysis, which necessitated exclusive rectal feeding from ten to eighteen days, was only in two cases attended with a fall of pressure, in one of which it did not exceed 10 mm. In some cases, indeed, the pressure at this period was raised for several days, thus suggesting an irritative condition of the vaso-motor centre in the medulla, in which the other nerves had undergone a varying degree of paralysis. Kolossova's statement that a fall of pressure preceded the occurrence of palatal and ciliary paralysis has not, to my knowledge, been confirmed by any subsequent observer. Allusion should here be made again to the work of Taddei, who drew special attention to the value of sphygmomanometry in the diagnosis of cardiac lesions in diphtheria. He found that when the blood-pressure was low there was an anatomical lesion of the myocardium, and held that in cases where the pressure was normal the cardiac disturbance might be ascribed to lesions of the cardiac nerve supply. It is principally in the acute stage of the disease that myocardial lesions, of which gallop rhythm is the most characteristic sign, are most likely to occur. It is at this period that the pressure tends to be low, whereas at a later stage during generalised paralysis all the signs of cardiac involvement except gallop rhythm may exist with a normal pressure. Taddei's observations, which are confirmed by my own, help to explain the better outlook of late diphtheritic paralysis, even when generalised, as compared with that occurring within the first fourteen days, when the vaso-motor centre primarily and secondarily the myocardium are affected The behaviour of the blood-pressure in early paralysis has already been illustrated in Tables IV and V. The following short histories show the course of the pressure in late paralysis:

Case 1.—Boy, aged 5 years, severe faucial diphtheria. Blood-pressure from second to ninth day 90 mm., from tenth to forty-sixth day 80 mm. Onset of pharyngeal palsy on forty-third day, necessitating rectal feeding till sixtieth day. Blood-pressure during this period as follows:

| Day of disease . | 43rd | 44th | 45th | 46th | 47th | 48th | 49th | 50th |
|---|---|---|---|---|---|---|---|---|
| Blood-pressure . | 80 | 80 morn.<br>80 even. | 90 | 90 | 100 | 100 | 100 morn.<br>100 even. | 100 |

| Day of disease | 51st | 52nd | 53rd | 54th | 55th | 56th | 57th | 58th | 59th | 60th |
|---|---|---|---|---|---|---|---|---|---|---|
| Blood-pressure | 100 | 100 morn.<br>100 even. | 100 | 100 morn.<br>90 even. | 90 morn.<br>90 even. | 90 morn.<br>90 even. | 90 | 90 morn.<br>90 even. | 90 | 90 |

Subsequent readings until discharge on ninety-eight day, 90 mm.

Case 2.—Girl, aged 4½ years, very severe faucial and nasal diphtheria. Blood-pressure from fifth to nineteenth day 80 mm., occasionally sinking to 70 mm., from twentieth to forty-first day 90. Onset of pharyngeal palsy on thirty-eighth day, necessitating rectal feeding till fifty-fourth day. Blood-pressure during this period:

| Day of disease. | 38th–41st | 42nd | 43rd–44th | 45th | 46th-51st | 53rd–54th |
|---|---|---|---|---|---|---|
| Blood-pressure . | 90 | 100 | 90 | 80 morn.<br>90 even. | 90 | 80 |

Subsequent readings ranged between 90 and 80 mm.

Case 3.—Girl, aged 5 years, severe faucial and mild laryngeal diphtheria. Blood-pressure on admission on seventh day 100 mm., from eighth to thirteenth day 90, from fourteenth to twenty-fourth

80 mm., from twenty-fifth to fortieth 90 mm. Pharyngeal palsy on forty-first, necessitating rectal feeding till fiftieth day. The blood-pressure during this period was invariably 90 mm.; on two occasions the measurements were taken morning and evening. From the fifty-first day till her discharge on the seventy-ninth the pressure remained the same, except on two occasions, when it fell to 80 and rose to 100 mm.

Case 4.—Girl, aged 2½ years, very severe faucial diphtheria. Blood-pressure on admission on fifth day 90 mm., from seventh to ninth day 80 mm., tenth to eleventh 70 mm., twelfth to sixteenth 70–60 mm., palatal palsy on twelfth day, seventeenth day 50 mm., eighteenth to twenty-fourth 70 mm., twenty-fifth to forty-first 80 mm. Onset of pharyngeal palsy on thirty-sixth day, necessitating rectal feeding until death from diaphragmatic paralysis on forty-eighth day. Blood-pressure during this period from thirty-sixth to forty-first day 80 mm., from forty-third to forty-seventh day 70 mm.

Case 5.—Boy, aged 7 years, very severe faucial diphtheria. Pharyngeal palsy on thirty-eighth day, necessitating rectal feeding till forty-ninth. Blood-pressure for ten days prior to pharyngeal palsy 110 mm. Blood-pressure during the twelve days' rectal feeding as follows:

| Day of disease | 39th–40th | 41st | 42nd | 43rd | 44th | 45th–46th | 47th | 48th | 49th |
|---|---|---|---|---|---|---|---|---|---|
| Blood-pressure | 110 | 100 | 110 | 106 | 98 | 96 | 100 | 94 | 90 |

Subsequently the pressure rose on the fifty-seventh day to 100 mm., at which it remained until his discharge on the eighty-seventh day.

*Prognostic value of sphygmomanometry in diphtheria.*—Has the estimation of the blood-pressure in diphtheria any value as a guide to prognosis? Does it afford any information which is not given by the ordinary methods of examination as to the progress of the case? These questions can best be answered by consideration of the blood-pressure in the fatal cases. Although in the majority of these the pressure took a progressively downward course, in some cases it might at first keep fairly steady, and then fall suddenly, remaining comparatively high until the day before death, or it might sometimes show a delusive rise after an initial fall, so that from a consideration of the blood-pressure alone it would be impossible to predict a fatal issue.

In none of these cases, however, did death take place unexpectedly, the characteristic features of malignant diphtheria having indicated the probability of a fatal termination before the blood-pressure had shown evidence of depression.

One may therefore conclude that the estimation of the blood-pressure, though of much theoretical interest and of some value in conjunction with other prognostic signs, is by no means indispensable in forming the prognosis of a case of diphtheria.

*Adrenalin therapy in diphtheria.*—The internal administration of adrenalin in severe diphtheria advocated by me in 1904, and in subsequent communications in 1908 and 1909, has since been adopted with favourable results by other observers. The doctrine of supra-renal insufficiency first introduced by Emile Sergent in 1902 has within the last two years been brought forward again by French clinicians, notably Netter, Hutinel, Moizard and Comby, to account for symptoms which had hitherto been attributed to cardiac failure, bulbar inhibition, or neuritis of the vagus. Netter's pupils, Baudoin and Gautier, have recently recorded in their inaugural theses cases of severe diphtheria, in which the blood-pressure was raised by internal administration of adrenalin.

In the present series 21 members of Class I and 13 of Class II were treated with adrenalin in 10 minim doses of the 1 in 1000 solution every two or four hours according to the severity of the attack. The relatively high pressure shown during the early days of the disease may, in part at least, have been due to the employment of this drug. It is a remarkable fact, however, as Martin and Darré have pointed out, that the ingestion of adrenalin in malignant diphtheria may cause the disappearance of prostration and asthenia without raising the arterial tension.

## SUMMARY.

(1) In a series of 179 cases of diphtheria the blood-pressure was found to be subnormal in 63 patients, or 35·1 per cent., the extent and duration of the depression having, as a rule, a direct relation to the severity of the faucial attack.

(2) In the great majority the highest readings were found in the first and the lowest in the second week of disease. The normal tension was usually re-established by the seventh week.

(3) In a large proportion of convalescent cases either the readings in the recumbent and erect positions were the same, or the recumbent was higher than the vertical record until convalescence was firmly established.

(4) In laryngeal cases disproportionately high readings were obtained, especially when the dyspnœa was sufficiently severe to require operation. Relief of the obstruction by tracheotomy was followed by an immediate and steep fall of blood-pressure (20 to 40 mm.).

(5) The blood-pressure showed little tendency to be affected by the early serum phenomena, but during the late febrile syndrome it was raised in 40 per cent.

(6) Albuminuria was accompanied either by a fall or by no change in the blood-pressure, except in a case of uræmia, in which there was hypertension.

(7) In early paralysis the blood-pressure tended to fall. In late paralysis, even when extensive, it was usually not affected.

(8) Sphygmomanometry in diphtheria, as in other acute diseases, though of considerable theoretical interest, has little practical significance.

(9) Adrenalin therapy in diphtheria may favourably influence the other symptoms of supra-renal insufficiency without affecting the blood-pressure.

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For further references to the subject of the blood-pressure in acute infections the reader should consult K. Weigert's admirable monograph, "Über das Verhalten des arteriellen Blutdrucks bei den akuten Infektionskrankheiten," Volkmann's 'Samm. klin. Vort.,' No. 459 (Serie xvi, Heft 9), Innere Med. No. 138.

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